

Attachment II

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Executive Office of Health and Human Services
Department of Public Health
Bureau of Environmental Health Assessment
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[REDACTED]

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Dear Mr. Moriarty:

Thank you for your telephone call concerning carbon dioxide measurements that were taken as part of the indoor air quality assessments conducted at the [REDACTED]. As you know, the Massachusetts Department of Public Health (MDPH) conducted two indoor air quality assessments at this facility during the past school year (MDPH, 2000a; MDPH, 2000b). These assessments examined the indoor air quality conditions that may have had an effect on building occupants. The status of the ventilation system, potential moisture problems/microbial growth and identification of respiratory irritants were examined in detail, which are described in both reports. In order to examine the function of the ventilation system, measurements for carbon dioxide, temperature and relative humidity were taken.

Carbon dioxide is an odorless, colorless gas. It is found naturally in the environment and is produced in the respiration process of living beings. Another source of carbon dioxide is the burning of fossil fuels. Carbon dioxide concentration in the atmosphere is approximately 250-600 ppm (NIOSH, 1987, Beard, R.R., 1982).

Carbon dioxide measurements within an occupied building are a standard method used to gauge the adequacy of ventilation systems. There are a number of reasons why carbon dioxide is used in this process. Any occupied building will have normally occurring environmental pollutants in its interior. Human beings produce waste heat, moisture and carbon dioxide as by-products of the respiration process. Equipment, plants, cleaning products or school supplies normally found in any school can produce gasses, vapors, fumes or dusts when in use. If a building has an adequately operating mechanical ventilation system, these normally occurring environmental pollutants will be diluted and removed from the interior of the building. This particular building has unit ventilators (univents), supplemented by rooftop air handling units (AHUs). Univents (see Figure 1) and AHUs, provide heat and fresh air during operation. The introduction of fresh air both

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increases the comfort of the occupants and serves to dilute normally occurring environmental pollutants.

An operating exhaust ventilation system physically removes air from a room and thereby removes environmental pollutants. The operation of univents and AHUs in conjunction with the exhaust ventilation system creates airflow through a room, which increases the comfort of the occupants. If all or part of the ventilation system becomes non-functional, a build up of normally occurring environmental pollutants may occur, resulting in an increase in the discomfort of occupants.

The MDPH approach to resolving indoor air quality problems is two-fold, 1) improving ventilation to dilute and remove environmental pollutants and 2) reduce or eliminate exposure from materials that may be adversely affecting indoor air quality. In the case of an odor complaint of unknown origin, it is common for BEHA staff to receive several descriptions from building occupants. A description of odor is subjective, based on the individual's life experiences and perception. Rather than test for a series of several hundred chemicals to identify the unknown material, carbon dioxide is used to judge the adequacy of airflow as it both dilutes and removes indoor air environmental pollutants. In the case where a specified environmental pollutant is known (e.g., carbon monoxide from vehicle exhaust odors or hydrogen sulfide from sewer gas), then air testing for those materials would be justified. MDPH staff do identify specific sources of pollutants that should be controlled or eliminated. By controlling or eliminating the source of respiratory irritants, a reduction in exposure to these airborne materials would occur.

As previously mentioned, carbon dioxide is used as a diagnostic tool to evaluate air exchange by building ventilation systems. The presence of increased levels of carbon dioxide in indoor air of buildings is attributed to occupancy. As individuals breathe, carbon dioxide is exhaled. The greater the number of occupants, the greater the amount of carbon dioxide produced. Carbon dioxide concentration build up in buildings is attributed to inefficient or non-functioning ventilation systems. At levels below 5,000 ppm, carbon dioxide does not pose a health risk, but rather is an indicator of how well the ventilation system brings in fresh air and removes stale air from the inside of a building.

Carbon dioxide can be a hazard within enclosed areas with **no air supply**. These types of enclosed areas are known as confined spaces. Manholes, mines and sewer systems are examples of confined spaces. An ordinary building is not considered a confined space. Air exposure limits for employees and the general public has been established by a number of governmental health and industrial safety groups as limitations on exposure to carbon dioxide. Each of these standards or air concentrations is expressed in parts per million (ppm). *Table 1* is a listing of carbon dioxide air concentrations and related health effects and standards.

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings (Redlich, 1997; Rosenstock, 1996; OSHA, 1994; Gold, 1992; Burge et al., 1990; Norback, 1990). A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Several sources indicate that

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indoor air problems *are significantly reduced* at 600 ppm or less of carbon dioxide (ACGIH, 1998; Bright et al., 1992; Hill, 1992; NIOSH 1987). Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches.

Air levels for carbon dioxide that indicate that indoor air quality may be a problem have been established for carbon dioxide by the American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE). Above 1,000 ppm of carbon dioxide, ASHRAE recommends adjustment of the building's ventilation system.

Permissible Exposure Limits (PELs) set limits on exposure for hazardous materials. PELs are established by the Occupational Safety and Health Administration (OSHA) for individual chemicals that can cause injury to exposed individuals. A PEL is a time-weighted average, which means that the air concentration of that substance must average out below the PEL over an 8-hour period of sampling. Temporary air concentrations above the PEL are allowed, as long as the overall 8-hour average remains below the PEL. However, air concentrations below the established PEL do not guarantee that exposed individuals will not have health effects. The PEL for carbon dioxide is 5,000 ppm.

Threshold Limit Values (TLVs) are the final set of standards that set limits on exposure for hazardous materials. TLVs are established by the American Conference of Governmental Industrial Hygienists (ACGIH) for individual chemicals that can cause injury to exposed individuals. A TLV is a time-weighted average, which means that the air concentration of that substance should average out below the TLV over an 8-hour period of sampling. These recommendations are designed to reduce the incidence of health effects in exposed employees. Again, air concentrations below the established TLV may still produce health effects in some exposed individuals. The TLV for carbon dioxide is 5,000 ppm (ACGIH, 1999).

Carbon dioxide has no acute (short-term) health effects associated with low level exposure (below 5,000 ppm). The main effect of carbon dioxide involves its ability to displace oxygen for the air in a confined space. As oxygen is inhaled, carbon dioxide levels build up in the confined space, with a decrease in oxygen content in the available air. This displacement of oxygen makes carbon dioxide a simple asphyxiant. At carbon dioxide levels of 30,000 ppm severe headaches, diffuse sweating, and labored breathing have been reported. At carbon dioxide levels above 50,000-100,000 ppm mental depression, visual effects, tremors, and unconsciousness are reported. No chronic health effects are reported at air levels below 5,000 ppm.

Air testing is one method to determine if carbon dioxide levels exceed the comfort levels recommended. If carbon dioxide levels are over 800-1,000 ppm, the MDPH recommends adjustment of the building's ventilation system. The Department recommends that corrective measures be taken at levels at or above 800 ppm of carbon dioxide in office buildings or schools.

In the specific case of the Furnace Brook Middle School, carbon dioxide levels measured in the building during the re-assessment were far lower than the previous visit

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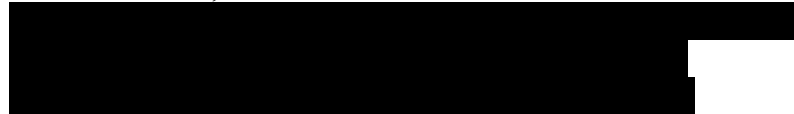
(MDPH, 2000b). These measurements indicate that the ventilation system was operating in an acceptable manner to create airflow to reduce normally occurring indoor environmental pollutants in the majority of areas tested. Please note that lower carbon dioxide levels in and of themselves may not decrease indoor air quality complaints.

In the case where renovation materials are penetrating into occupied areas, an adequately operating ventilation system would not be sufficient to prevent exposure. As recommended in the first assessment, proper contaminant and exhaust ventilation of the space under renovation will isolate the occupied areas of a building from pollutants. Therefore, the MDPH strategy of adequate ventilation coupled with pollutant source reduction/removal serves to improve indoor air quality in a building. Please note that in each table, the carbon dioxide levels between 600 ppm to 800 ppm are acceptable and <600 ppm is preferable for comfort (MDPH, 2000a; MDPH, 2000b). While carbon dioxide levels are important, focusing on these air measurements in isolation to all other recommendations is a misinterpretation of the recommendations made in these assessments.

Sincerely,

Michael A. Feeney, R.Ph., J.D., C.H.O.
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cc/ Suzanne Condon, Director, BEHA
Cory Holmes, BEHA
Suzan Donahue, BEHA



Senator Robert Hedlund
Representative Frank Hynes

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Table 1

Carbon Dioxide Level	Health Effects	Standards or Use of Concentration	Reference
250-600 ppm	None	Concentrations in ambient air	Beard, R.R., 1982 NIOSH, 1987
600 ppm	None	Most indoor air complaints eliminated, used as reference for air exchange for protection of children	MDPH, 2000a NIOSH, 1987
800 ppm	None	Used as an indicator of ventilation inadequacy in schools and public buildings, used as reference for air exchange for protection of children	MDPH, 2000b OSHA, 1994
1000 ppm	None	Used as an indicator of ventilation inadequacy concerning removal of odors from the interior of building.	ASHRAE, 1989
5000 ppm	No acute (short term) or chronic (long-term) health effects	Permissible Exposure Limit/Threshold Limit Value	ACGIH, 1999 OSHA, 1997
30,000 ppm	Severe headaches, diffuse sweating, and labored breathing	Short-term Exposure Limit	ACGIH, 1999 ACGIH. 1986
40,000 ppm		Immediately Dangerous to Life and Health Level (IDLH)	NIOSH, 1997
50,000-100,000 ppm	Mental depression, visual effects, tremors, unconsciousness		ACGIH, 1986 Sittig, 1985